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Flavor of Recombined Milk

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Abstract

Anhydrous butteroil homogenized into reconstituted nonfat milk powder formed a recombined milk, the flavor score of which was relatively close to that of fresh pasteurized milk. When these milk components were packed in nitrogen and stored at −18 C for six months no change in flavor of the recombined milk was noted. Higher storage temperatures caused changes in the butteroil which resulted in a stale flavor appearing in the recombined material. Recombined products made from butteroil stored at 27 C for two months were judged definitely stale. Molecular distillation at 1 μ pressure at temperatures up to 200 C removed from deteriorated butteroil some but not all of the components responsible for stale flavor. Under the packaging and storage conditions of the experiment, changes in the composition of the nonfat powder were not of sufficient magnitude to affect the flavor of the recombined milks.

Recombined milk is a beverage made by mixing butter or butteroil, skim solids, and water in proportions simulating the composition of fresh milk.

The sparse literature on this subject, extending back to near the start of this century (14), contains nothing about the organoleptic properties of this product or factors that could influence them.

In view of the continued growth of milk recombining operations overseas, and the upsurge of interest in the use of this product for the feeding of people in developing nations, we present data pertaining to the flavor of this product and some factors that influence it. We shall also relate our results to published information concerning flavor changes in stored, dehydrated whole milk.

Materials and Methods [1]

Mixed herd milk from the Agriculture Research Center was separated at 4 C, except where noted, to provide the skimmilk and cream used in all experiments.

Anhydrous butteroil was made by churning cream pasteurized by holding at 77 C for 15 sec and melting the resultant butter at 43 C. The butteroil was freed of protein by repeated washing with water. Residual water and air were finally removed by holding the oil at 43 C for two hours under vacuum (pressure 1 mm).

Nonfat dry milk was made from skimmilk pasteurized at 77 C for 15 sec using the foam-spray-drying operation as described by Bell et al. (2), except that nitrogen rather than air was injected into the concentrate at the rate of 12.5 standard liters/kg of concentrate to produce the foamed powder. The powders produced in this fashion contained 2.0% moisture, 1.6% fat, and 0.11% phospholipid as determined by the standard Mojonnier procedure and other published methods (3, 9).

Samples of nonfat dry milk having fat content reduced to 0.8% were prepared by applying the above procedure to skimmilk obtained by separating mixed herd milk at 43 C.

Samples of butteroil and nonfat dry milk were packed in no. 1 tins under nitrogen using a procedure previously described (16). The fat samples were held at 43 C at a pressure of 1 mm for 18 hr before filling with prepurified nitrogen ($O_2 < 0.002\%$) to a pressure of 1.5 atmospheres and sealing. The cans containing nonfat dry milk were held at 27 C under similar conditions before filling with nitrogen and sealing.

Samples of both fat and nonfat dry milk were stored at −18, 4, and 27 C. During storage, samples were taken at appropriate intervals and recombined by dispersing 100 g powder in 1,000 ml water, warming the skimmilk to 60 C, adding 36 ml of butteroil warmed to 43 C, and homogenizing the mixture at 141 kg/cm², using a Manton-Gaulin Model 15-M homogenizer. The stored materials were also combined with either freshly made butteroil or fresh skimmilk to form a simulated whole milk as above.

The flavor of all samples was evaluated, using a ten-man skilled-judge taste panel operating with a ten-point scale ranging from 31 to 40 (8).

The efficiency of molecular distillation as a

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[1] Reference to certain products or companies does not imply an endorsement by the Department over others not mentioned.

means of removing off-flavored material developed in butteroil during storage was investigated using a Rotafilm 5-cm molecular still (Arthur A. Smith, Inc., Rochester, New York). After passage through the still, the fat samples were recombined with fresh skimmilk and the flavor of the product evaluated.

Results

Results from the expert judges' evaluation of the flavor of recombined milks, made from stored and fresh milk components, are shown in Table 1. The average flavor score of all recombined products was lower than that of fresh whole milk, whose average score is about 37 in our locality. Greatest deviation from fresh whole milk flavor was noted where samples of butteroil stored at 27 C were combined with skimmilk or reconstituted nonfat dry milk. It is also apparent that the chemical changes occurring in the butteroil during storage are the most important factors in determining the flavor of recombined milk. The rate of this change is very slight or nonexistent during the first six months of storage at −18 C.

TABLE 1
Development of staling in samples stored at various temperatures

Samples	Flavor score	Stale criticisms[a]
Initial		
Fresh fat + fresh NDM	36.0	5
−18 C storage[b]		
Fresh fats + fresh skimmilks	35.6	4.8
Fresh fats + stored NDM	35.2	4.3
Stored fat + fresh skimmilks	35.7	3.3
Stored fat + stored NDM	35.7	4.5
4 C storage[b]		
Fresh fats + fresh skimmilks	35.6	4.8
Fresh fats + stored NDM	34.9	5.5
Stored fat + fresh skimmilks	35.0	6.5
Stored fat + stored NDM	35.1	6.3
27 C storage[b]		
Fresh fats + fresh skimmilks	35.6	4.8
Fresh fats + stored NDM	35.3	4.8
Stored fat + fresh skimmilks	33.8	7.8
Stored fat + stored NDM	33.8	7.0

[a] Average number per sample out of ten possible.
[b] Average values of samples taken after separate storage for 12, 20, 25, and 30 weeks of one fresh fat and one fresh NDM.

The acceleration of flavor score decrease by higher storage temperatures is shown in Table 2. The greatest flavor decrease due to changes in the butteroil occurred during the first two months of storage at 27 C. Little change in the off-flavor from the fat is noted on continued storage.

TABLE 2
Effect of storage temperature on flavor score of milk fat

Storage tempera-ture	Flavor score relative to that of fat held at −18 C for indicated storage period[a]		
	2 months	4 months	6 months
4 C	−0.4	−0.6	−0.6
27 C	−1.0	−1.2	−1.1

[a] Averages obtained from ten milk fats. Recombinations were made at each tasting period with fresh skimmilk.

The materials developing in butteroil stored at elevated temperature which contribute to off flavor in recombined products are difficult to remove by molecular distillation. This is shown in Table 3. Recombined products made from fresh skimmilk and stored fats subjected to molecular distillation have flavor scores that demonstrate only partial off-flavor constituent removal, even at distillation temperatures of 200 C. The flavor of products made from butteroil stored for 16 months at −18 C cannot be improved by molecular distillation of the fat

TABLE 3
Removal of off-flavor from 16-months-old fat samples by molecular distillation

	Control (not dis-tilled)	Temperature of distillation		
		100 C	150 C	200 C
−18 C storage				
Flavor score	35.8	35.6	35.9	35.9
Stale criticisms[a]	3	5	4	5
4 C storage				
Flavor score	34.8	35.3	35.5	35.9
Stale criticisms[a]	6	5	6	4
27 C storage				
Flavor score	34.1	35.2	35.7	35.1
Stale criticisms[a]	8	6	5	5

[a] Number of criticisms per sample out of ten possible.

before recombination. However, the flavor of products made from fats stored an equal time at higher temperature is improved by molecular distillation of the butteroil before recombination is attempted.

None of the data from our flavor study of recombined milk gave any indication that changes occurring during storage of the gas-packed nonfat dry milk had influenced the flavor of the finished product. Changing the fat content of the nonfat dry milk from 1.6 to 0.8% by elevating the separating temperature during processing did not significantly change the storage stability of the powders or influence the flavor of the recombined milks made therefrom.

Discussion

Butteroil homogenized into reconstituted skimmilk powder in proportions similar to whole milk produces a beverage of good quality, even though expert judges consistently scored it lower than fresh pasteurized milk.

This lowered initial flavor score was not attributed to the loss of the buttermilk fraction during processing of butteroil. Preliminary experiments in our laboratory indicated that inclusion of buttermilk in recombined products tended only to slightly improve their tactual qualities. Since judges varied widely in their response to this quality, the buttermilk fraction was deliberately excluded from the material used in our studies.

When butteroil and nonfat dry milk are gas-packed in nitrogen and recombined after six months of storage at −18 C, a beverage having flavor almost indistinguishable from that observed at the start of storage was obtained.

The decline in the flavor of recombined milks made from butteroil and nonfat dry milk stored at higher tmperatures arises principally from changes in the fat phase. The rate of this change is temperature-dependent. At 27 C the rate of change is sufficient to produce a definite stale flavor in recombined milk made from butteroil stored two months or longer.

While the term stale as used in our scoring system is somewhat vague and unsatisfactory, it was the consensus of the judges that it relates to flavors associated with lactone formation in milk fat. This would be anticipated from the pioneer work on these compounds by Keeney and Patton (7).

The reaction of our panel judges to the recombined milks made using butteroil stored at 27 C and to foam-dried whole milk packed in tins containing near-zero levels of oxygen and stored at elevated temperatures (16) was very similar. This tends to further corroborate the work of Patton et al. (13) and Whitney et al. (17), who presented evidence that the nonoxidative changes in dehydrated whole milk known as staling may result primarily from changes in the fat phase.

Even though the data presented here show the nonfat dry milk to undergo very little or no flavor change during the storage periods investigated, it must be noted that the powders were high quality, low moisture materials, carefully packed in inert gas.

Keeney (6), Parks et al. (11), and Henry et al. (5) have already demonstrated that less carefully handled nonfat dry milk undergoes chemical changes during storage which are deleterious to the flavor of the reconstituted material. The sensitivity of the nonfat dry milk to change during storage has been recognized to some extent by the recombined milk manufacturers. When a high quality recombined milk is desired, not only are the powder and fat refrigerated, but gas packing of the nonfat dry milk is practiced.

The changes that occur during the processing and storage of butteroil for recombination purposes may be difficult to rectify. Our use of a molecular still to clean up deteriorated butteroil indicates that some of the off-flavored compounds in the oil have a low order of volatility and cannot be completely distilled off directly, even under extreme conditions.

A more fruitful pathway to improved recombined milk may be through use of steam deodorization of the butteroil, as described by Patton (12) and Nelson et al. (10). However, if this is to be pursued, a question arises as to the ultimate advantage of recombined milk over the improved whole milk powder that can be made by foam-spray drying (4) or vacuum belt drying (1), and packed with an efficient oxygen scavenger now available (15).

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